Horticulture Department Series 417 January 1975

A PRELIMINARY REPORT

on

MASS SORTING OF

MECHANICALLY HARVESTED TOMATOES

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ACKNOWLEDGEMENTS

The author is deeply indebted to: (1) the Tomato Research Committee of the Ohio Canners and Food Processors Association for planning the project. The committee consisted of Richard Boucher, Bryan Canning Co.; Fred Binger, Libby, McNeill & Libby; William Hirzel, Hirzel Canning Co.; Thomas H. Timmer, Tip Top Canning Co.; Rodney Wohlers, Hunt-Wesson Foods; Henry Reichman, Libby, McNeill & Libby; Lynn Roseman, FMC Corporation; Jack Scheid, Chisholm Ryder Co.; H. A. Rollins, Jr., OSU-OARDC (2) the following firms for substantial financial contributions: Beckman & Gast Co., St. Henry; Bryan Canning Co., Bryan; Del Monte Corp., Rochelle, Illinois; H. J. Heinz Co., Bowling Green and Fremont; Hunt-Wesson Foods, Toledo; Libby, McNeill & Libby, Leipsic; Minster Canning Co., Minster; Stemley Canning Co., New Weston; and Tip Top Canning Co., Tipp City; (3) the following firms for loaning equipment: General Kinetics Inc., Rockville, Maryland; Libby, McNeill & Libby, Leipsic; Hirzel Canning Co., Toledo; (4) the following firms and personnel who made significant contributions throughout the study: (A) Libby, McNeill & Libby: Fred Binger, Larry Holl, Henry Reichman, Ken Holloway, Tom Valvoda, Dave Schultz (B) FMC Corporation: Lynn Roseman (C) Chisholm Ryder Corp.: Jack Scheid (D) OSU-OARDC personnel: Betty Fogg, Jacquelyn Gould, James Ice, Deanna Johnson, Donald Mount, John Mount, LaVon Riegel, Marilynn Skoog, Jerry Stillabower, Ruth Stillabower, Cheryl Thompson, Judy Wheeland, and Jerry Wright.

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Wilbur A. Gould[1]

INTRODUCTION

At the present time mechanical harvesting of tomatoes is a reality, at least in the West. In the Midwest, due to the lack of uniformity of fruit ripening, 70% or more of the tomato crop is still hand harvested. However, with new tomato cultivars, the use of Ethrel, and insufficient labor for hand harvesting, mechanical harvesting of tomatoes may be a reality for the Midwest in the immediate years ahead. Most authorities agree that when mechanical harvesting becomes a full reality in the Midwest, it will not be economically feasible to utilize the present amount of labor on the harvester to sort the tomatoes into useable and unuseable fruit. This is probably more critical in the Midwest than in the West as the westher conditions do not permit uniform field ripening. Alternative methods of sorting the crop other than on the tomato harvester are needed.

The quality of processed tomatoes is directly related to the quality of the raw tomato. Quality includes color (maturity), free from defects, soil, and other attributes. Raw tomato maturity for processing implies the percentage of red color determined subjectively or the new USDA standard using the tomato colorimeter for tomato pulp color. Generally, the raw tomato color is defined as the percentage of Number 1's or Number 2's with Number 1 having

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90% red color and Number 2 with 66-2/3% red color or the TCM value of 63 or more.

Another measure of tomato maturity is specific gravity or percent tomato solids. Even though the change of maturity may be small, the specific gravity is significant and tomatoes can be evaluated for maturity by specific gravity separation techniques. Kattan, et al, in 1968 and 1969 reported on the FTC mass mechanical sorter for tomatoes using brine solutions (1 & 2). Gutterman has shown that mass quality separation of tomatoes utilizing the differences of specific gravity between green and defective fruit vs. ripe and sound fruit can be obtained by separation in a body of water using the FTC sorter (3).

OBJECTIVES

The basic objectives of this study were to determine: (1) the feasibility of mechanically harvesting tomato cultivars with little or no labor for sorting of fruits on the harvester, (2) the feasibility of sorting mechanically harvested tomatoes by cultivars for quality at the processing plant utilizing the water separation techniques, and (3) the evaluation of dry cleaning of tomatoes using the Western Regional Utilization Laboratory disc system.

Preceding and/or concurrently with the use of mechanical harvesting with no harvester sorting systems, emphasis must be given to a critical evaluation of existing and newly developed cultivars for uniform ripening, acceptable yields to the grower, and acceptable qualities to the processor.

PILOT LINE LAYOUT

A pilot line was designed at the Libby, McNeill & Libby plant at Leipsic, Ohio to handle a minimum of three tons of tomatoes per hour in lots of approximately 1,000 pounds. The line consisted of a dump tank with a conveyor out of the dump tank; vine and trash conveyor eliminator; dry disc cleaner; modified FTC water separator with three take off belts and controls for water velocity, air injection and water temperature control, and three sorting belts. In addition, facilities for collection and weighing different qualities of fruits and the determination of specific gravity from each sorting belt were part of the pilot line. A schematic layout of the line is shown in Figure 1. A detailed layout of the mass specific gravity separator is shown in Figure 2. Photos 1 through 3 give further visual description of the line.

PROCEDURES

A. <u>Cultivars</u>

Four cultivars (Libby A, Libby B, C-28, and a pear cultivar) supplied by the Libby, McNeill & Libby firm were used for the basic studies. These were all machine harvested with little or no sorting on the harvester other than eliminating the large clods of dirt and vines and removing useable fruit from the dirt belt. Approximately, 56,000 pounds of fruit were used from the Libby firm.

Thirteen cultivars from the cultivar evaluation plots were harvested at the Northwest Branch of the OARDC at Hoytville. They were likewise machine harvested with little or no sort on the harvester except as noted above. Approximately one ton of fruit was harvest from each cultivar with a total of 24,595 pounds. These thirteen cultivars were handled for this report as one lot. In all, 80,778 pounds of fruit were harvested and water sorted in 73 separate runs during the season.

B. Quality of Fruit

As the tomatoes were run by each specific cultivar, the percent useable fruits (theoretical reds) were determined visually on the basis of color. Further, the specific gravity was calculated on a 5-8 pound sample of both the useable and unuseable fruits by weighing the sample in air and in water. The weights of both the useable and unuseable fruits were recorded from all take off conveyors for each run and used to determine the efficiency of the mass sorting operation.

C. Quality of Water

In addition the water in the dump tank and the specific gravity separator were sampled at the start, during and at the end of each days run. They were evaluated for changes in pH, soluble solids, total solids, total volatile solids, volative suspended solids, and chemical oxygen demand(COD) using standard methods.

D. Pilot Line Operation

Generally, 1,000 pounds of tomatoes of each cultivar lot were dumped in the dump tank at the rate of 100 pounds per minute while the pilot line was in operation. The only adjustments made during a run were (1) velocity of the water in the mass specific gravity separator ranging from 550 to 800 rpm's on the propeller (2) the level of the water which controlled the depth of the take off conveyor in zone 1 and 2 (3) the location of the take off conveyors for zone 1 and 2 with respect to the entry of the fruit in the water (4) the temperature of the water from ambient up to 100°F. and (5) the use of a detergent in the mass specific gravity separator. During the early runs an additional variable consisted of feeding the tomatoes in the bottom of the tank as originally designed on the FTC unit vs. direct feed into the top of the unit. Most of the data were taken by direct feed as the FTC method caused a plugging of the unit, particularly with the pear shaped cultivar.

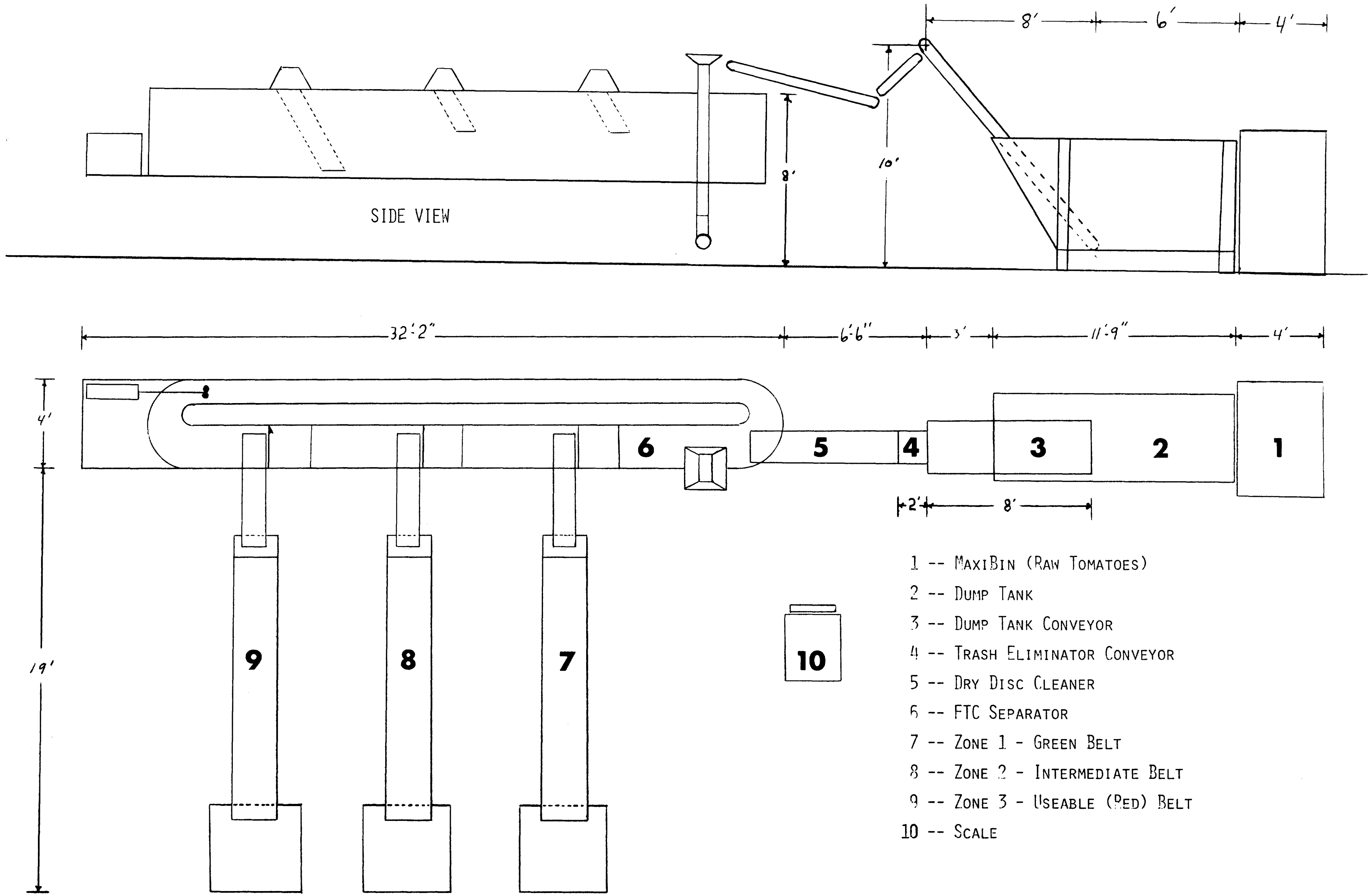

FIG. 1.--Schematic Layout of Pilot Line for Cleaning and Water Separation of Tomatoes.

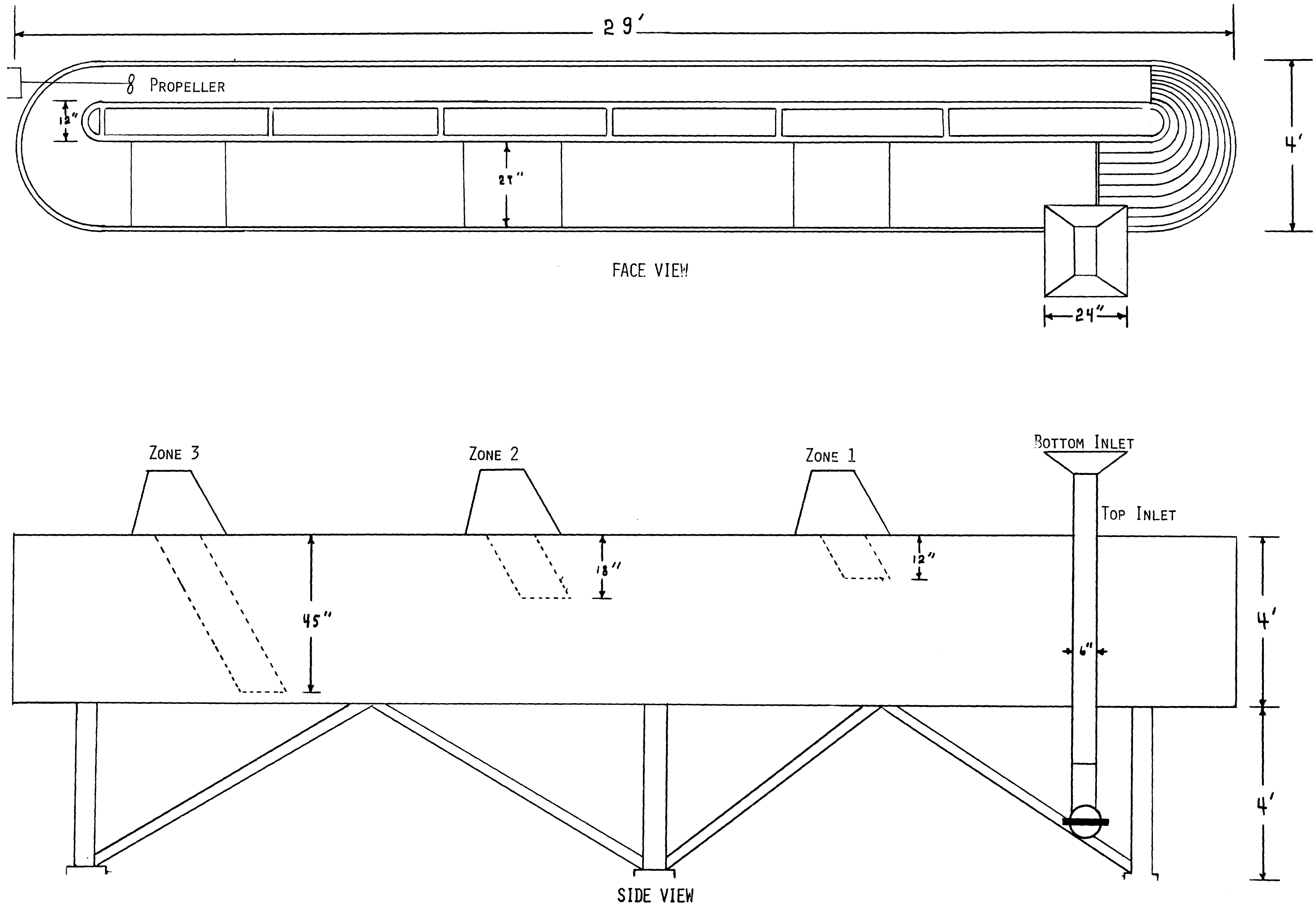

FIG. 2.--FTC Mass Specific Gravity Separator.

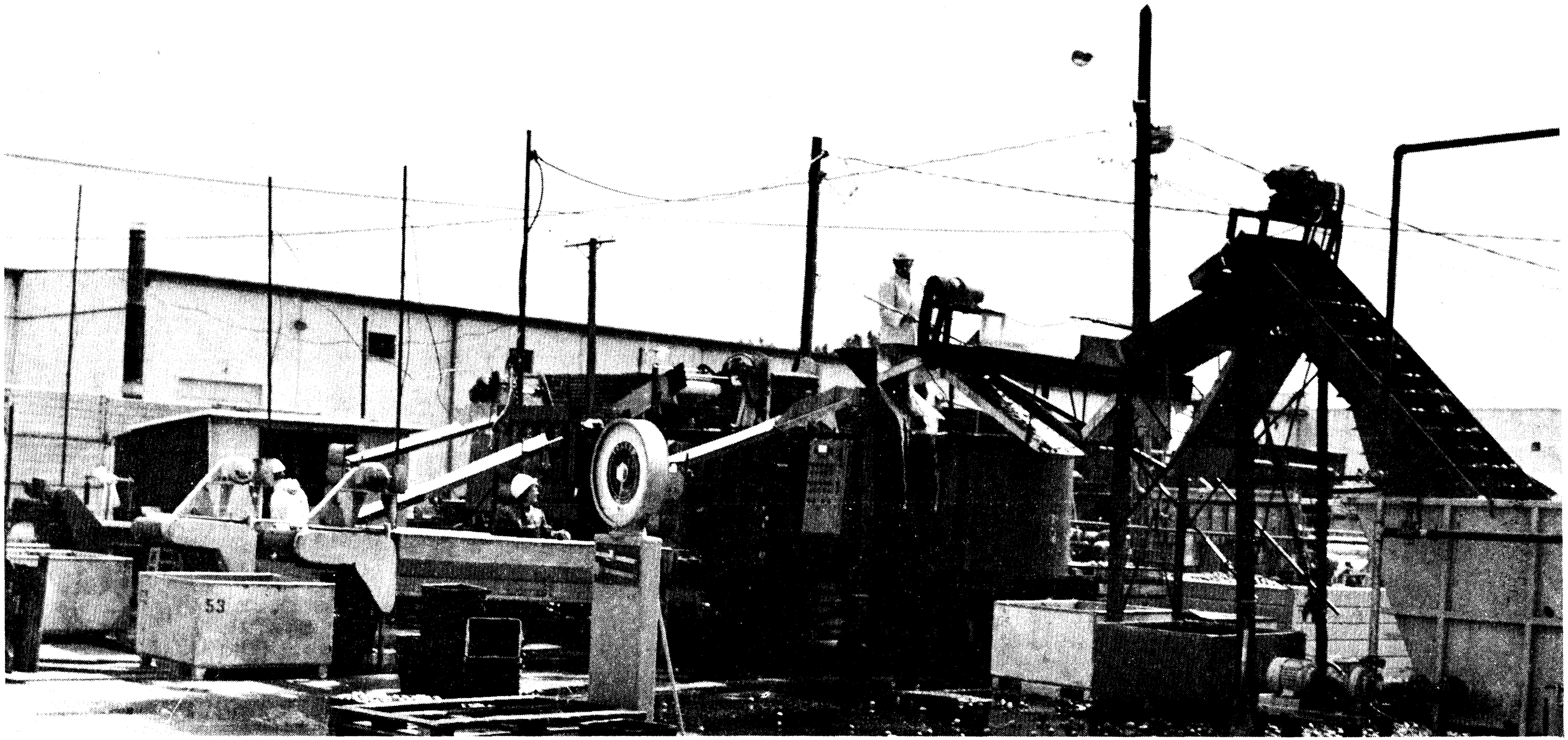

PHOTO 1.--Pilot plant line for separation of tomatoes.

PHOTO 2.--Specific gravity separator showing belts lifting fruits out of the water separator.

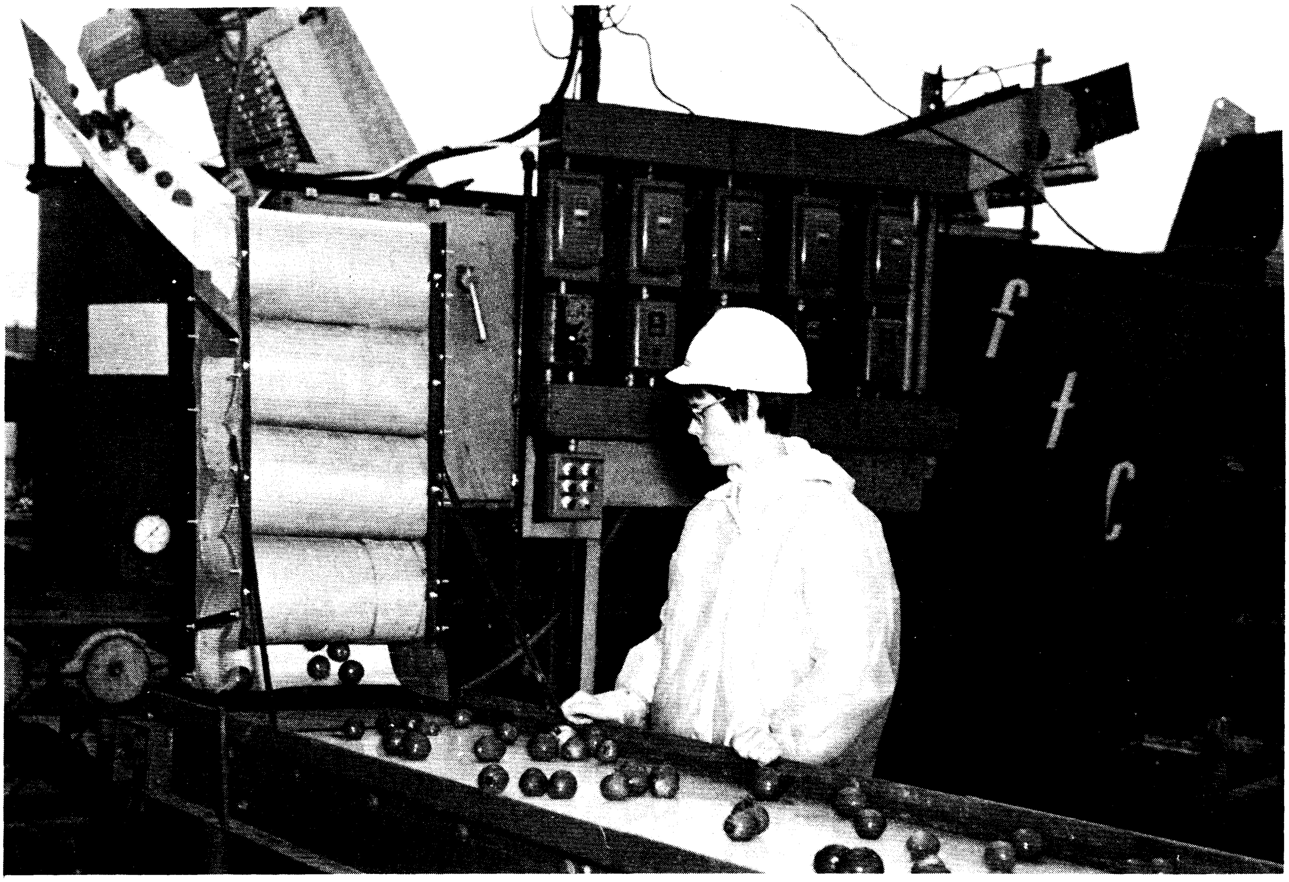

PHOTO 3.--Zone 3 discharge conveyor and sorting belt.

RESULTS

There was a total of 73 runs throughout the season with 80,383 pounds harvested and separated. The average theoretical reds (mature ripe fruit) varied by cultivars from a low of 48.5% reds from the average of the OARDC cultivars to a high of 97.4% reds for the Libby pear variety. The actual reds that were water sorted ranged from a low of 43.8% for the average of the OARDC varieties to a high of 84.3% for the C-28 variety (Table 1).

The data in Chart 1 is a theoretical vs. actual weights of reds showing a correlation of .87 for the various runs throughout the season. The data in Chart 2 show the theoretical reds and actual reds in percent with pounds for each of the cultivar lots and the calculated efficiencies for each.

The data presented in Table 1 summarizes the totals or averages for the runs by cultivars or lots for the season. The important comparisons are in percent useable or theoretical reds vs. the percent useable sorted or actual reds. As an example, for Libby A there were 28,537 pounds sorted, with a percent useable or theoretical reds of 74.4% and actual reds water separated in zone 3 of 66.4%. For Libby B, 18,284 pounds with 68.7% vs, 41.9%. Considerable more difficulty was encountered with this cultivar for some of the runs, causing the percentages to be down; but, as adjustments were made between the runs with the cultivar, the data indicates that it can be separated nearly as efficiently as for the Libby A cultivar. With the C-28 cultivar the percent useable for the 6,988 pounds was 79.2% theoretical red with an actual separation of 76.4%.

The average of the 13 cultivars from the OARDC trials amounted to 27,595 pounds with only 48.5% theoretical ripe; however, the separation was 36.6%.

Another way to interpret the data is to calculate the percent efficiency of the separator by taking the total pounds of useable fruit separated in zone 3 over the total pounds of useable fruit in all three zones (theoretical reds). Here calculations show an overall efficiency of 80.0% for 80,778 pounds with a low of 61.0% efficiency for Libby B and a high of 97.0% efficiency for C-28.

The data in regards to monitoring the changes in water quality for the separator are shown in Charts 3 thru 7. Generally, it will be noted that there was not an excessive buildup of solids in the separator. Further the COD values were extremely low. The COD values in the cleaner and dump tank were much higher. This would be attributed to the wide range of soil or dirt coming in with the harvested fruit during the wet weather for some of the harvests. These data clearly indicate the ability of the disc cleaner to clean the fruit before being water separated.

Table 1 SUMMARY EVALUATION OF WATER SEPARATION OF TOMATOES BY CULTIVARS SHOWING WEIGHTS & CALCULATED PERCENTAGES BY SEPARATOR ZONES AND EFFICIENCY

Code for Calculations*	Cultivar	Pear	Libby A	Libby B	C-28	OARDC	Total or Average
1.	Number of Runs	3	21	17	6	26	73
2.	Total Weight (lbs.) Separated	2554.0	28357.0	18284.0	6988.0	24595.0	80778.0
3.	% useable (theoretical red)	97.4	74.4	68.7	79.2	48.5	66.4
4.	% unuseable (theoretical green)	2.6	25.6	31.3	20.8	51.5	33.6
5.	specific gravity useable	1.109	1.102	1.086	1.145	1.093	1.107
6.	specific gravity unuseable	1.074	1.027	1.029	1.090	1.049	1.053
7.	zone 1 useable (lbs.)	342.0	1670.0	4129.0	68.0	2441.0	8650.0
8.	useable (%)	85.1	23.8	45.5	10.4	19.2	29.0
9.	zone 1 unuseable (lbs.)	60.0	5357.0	4948.0	589.0	10259.0	21213.0
10.	unuseable (%)	14.9	76.2	54.5	89.6	80.8	71.0
11.	zone 2 useable (lbs.)	185.0	574.0	776.0	125.0	473.0	2133.0
12.	useable (%)	97.9	62.1	74.7	30.8	42.2	58.0
13.	zone 2 unuseable (lbs.)	4.0	351.0	263.0	281.0	648.0	1547.0
14.	unuseable (%)	2.1	37.9	25.3	69.2	57.8	42.0
15.	zone 1 + zone 2 useable (lbs.)	527.0	2244.0	4905.0	193.0	2914.0	10783.0
16.	useable (%)	89.2	28.2	48.5	18.2	21.1	32.2
17.	zone 1 + zone 2 unuseable (lbs.)	64.0	5708.0	5211.0	870.0	10907.0	22760.0
18.	unuseable (%)	10.8	71.8	51.5	81.8	78.9	67.8
19.	zone 3 useable (lbs.)	1961.0	18839.0	7665.0	5340.0	9005.0	42810.0
20.	useable (%)	99.9	92.3	93.8	90.1	83.6	90.6
21.	zone 3 unuseable (lbs.)	2.0	1566.0	503.0	585.0	1769.0	4425.0
22.	unuseable (%)	.1	7.7	6.2	9.9	16.4	9.4
23.	total zone 1 + zone 2 (lbs.)	591.0	7952.0	10116.0	1063.0	13821.0	33543.0
24.	total zone 1 + zone 2 (%)	23.1	28.0	55.3	15.2	56.2	41.5
25.	total zone 3 (lbs.)	1963.0	20405.0	8168.0	5925.0	10774.0	47235.0
26.	total zone 3 (%) (useable+unuseable)	76.9	72.0	44.7	84.8	43.8	58.5
27.	% useable (actual reds) sorted	76.8	66.4	41.9	76.4	36.6	53.0
28.	calculated efficiency (useable fruit)	79.0	89.0	61.0	97.0	76.0	80.0

* 3=(15+19/2) x 100. 4=(17+21/2) x 100. 8=(7/7+9) x 100. 10=(9/7+9) x 100. 12=(11/11+13) x 100 14=(13/11+13) x 100. 16=(15/23) x 100. 18=(17/23) x 100. 20=(19/19+21) x 100. 22=(21/19+21) x 100. 24=(23/2) x 100. 26=(25/2) x 100. 27=(19/2) x 100. 28=(19/15+19) x 100.

SUMMARY

Differences were encountered early in the season while learning to operate the equipment, but after the equipment parameters were known, it was definitely feasible to separate useable from unuseable fruits by the specific gravity water technique. Only one take off conveyor is needed to remove the green fruit with this being adjusted in depth and proximity to entry based on the cultivar of tomatoes being run. An average efficiency for the C-28 cultivar ran as high as 97.0% with a low of 61.0% for the Libby B cultivar. Overall, the calculated efficiency was 80.0% for all cultivars.

The specific gravity equipment should permit the separation of the useable fruits from the unuseable fruits. The useable fruits sink to the bottom and are removed with a drag conveyor. The unuseable fruits (green and defective) float and are removed by a take off belt located near the water surface.

Detergents are not necessary, but the temperature of the water should be adjusted, particularly, when sorting cold fruits. The unit was more effective when the water in the separator was 20°F higher than the fruit temperature.

Tomatoes can be machine harvested with little or no sort on the harvester other than labor for removing clods and vines. The dry disc cleaner is a must to keep the water clean in the separator. The tomatoes were cleaned efficiently with little or no buildup of solids or COD's in the separator. The dry disc cleaner did an excellent job of removing smear soil.

Man hour records were maintained for each operation, but generally no more than 2 people were required for the final sorting of the tomatoes. One operator would be required to operate the line to make adjustments, due to the cultivar differences.

Defective fruits, as indicated in the latter part of the season, were removed with the separator in zone 1 or the unuseable belt. These were removed with the green fruits indicating that entrapped air caused these fruits to rise rapidly in the water systems.

The average specific gravity difference for the ripe fruits vs. the green fruits was 0.054, indicating that a definite difference was obtained. This principle was the one proven successful for separating useable from unuseable tomatoes.

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2. Kattan, A. A., Sharp, C. Q., and Morris, J. R. "A Mechanical Sorter for Tomatoes", Arkansas Farm Research, 18(1), 1969.

3. Gutterman, R. P. "A Mass Flow Density Sorter for Fruits and Vegetables"., Food Technology Corp., Rockville, Maryland.

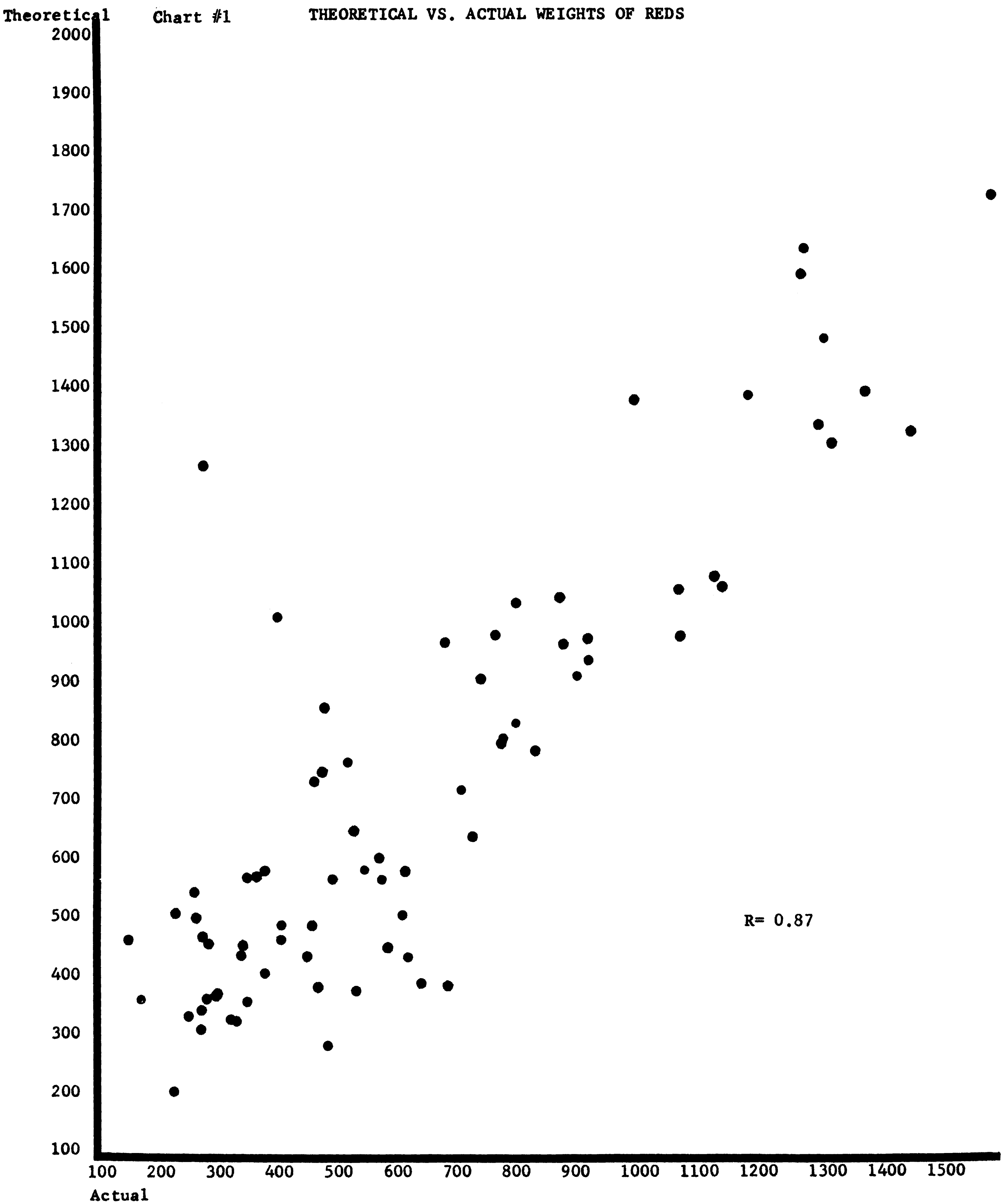

Theoretical
Chart #1
THEORETICAL VS. ACTUAL WEIGHTS OF REDS
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
R= 0.87
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
Actual

Chart 2 COMPARISON OF THEORETICAL REDS VS. ACTUAL SPECIFIC GRAVITY SEPARATED REDS IN % BY CULTIVARS WITH TOTAL POUNDS AND CALCULATED EFFICIENCY

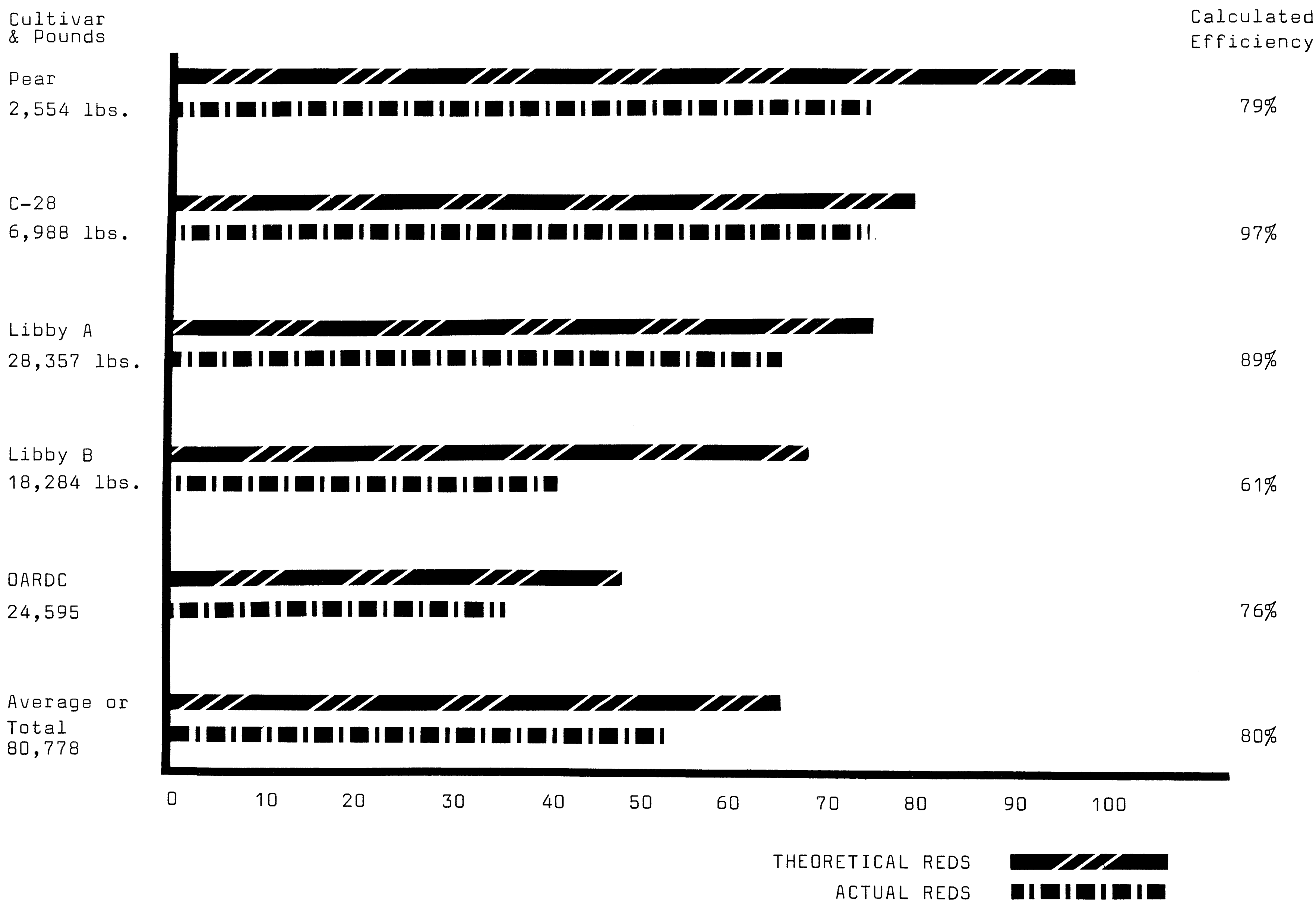


CHART 3

INCREASE IN TOTAL FIXED SOLIDS FOR SEPARATOR BY EACH DAYS RUN

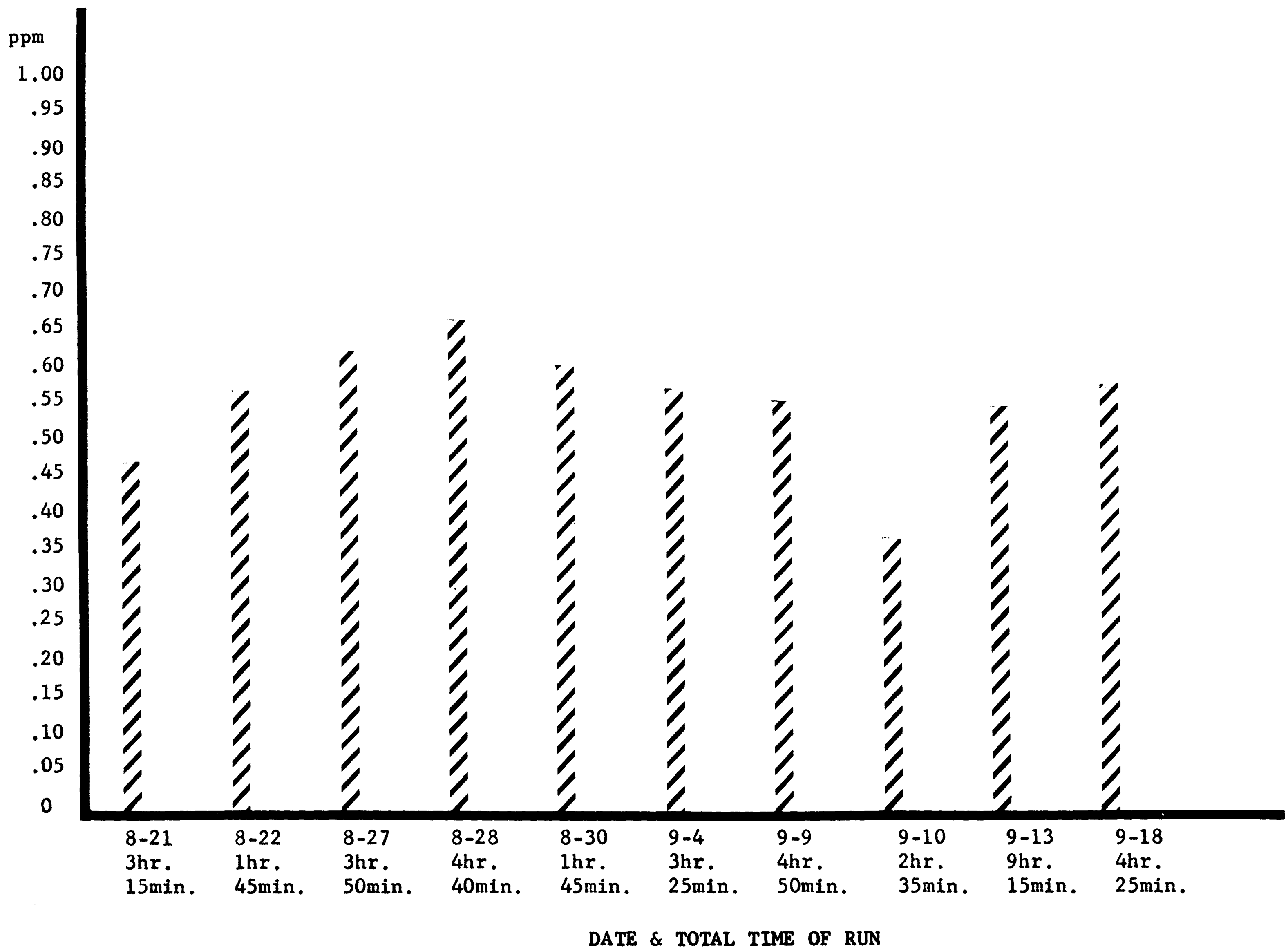


CHART 4

INCREASE IN TOTAL VOLATILE SOLIDS FOR SEPARATOR BY EACH DAYS RUN

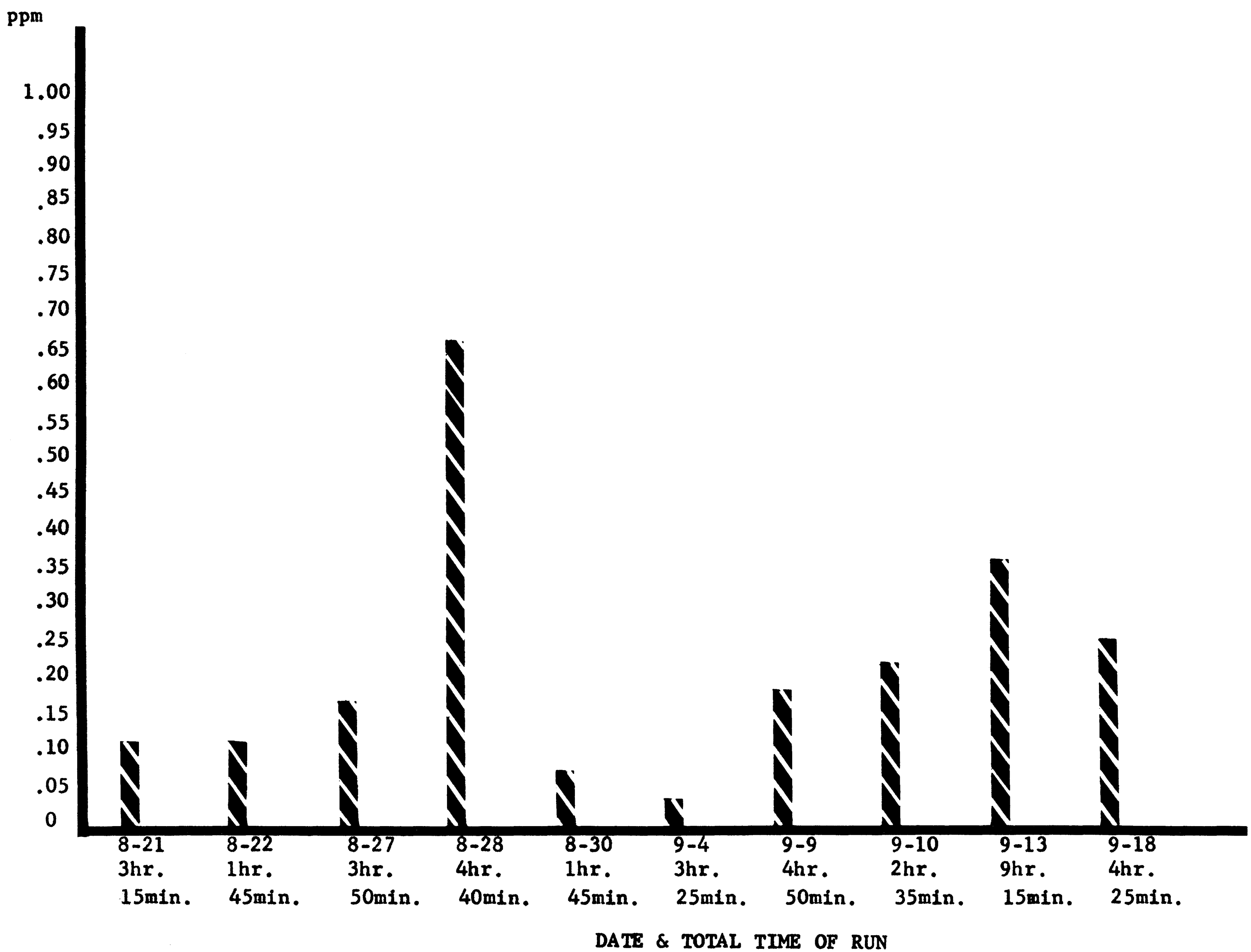


CHART 5

INCREASE IN SOLUBLE SOLIDS FOR SEPARATOR BY EACH DAYS RUN

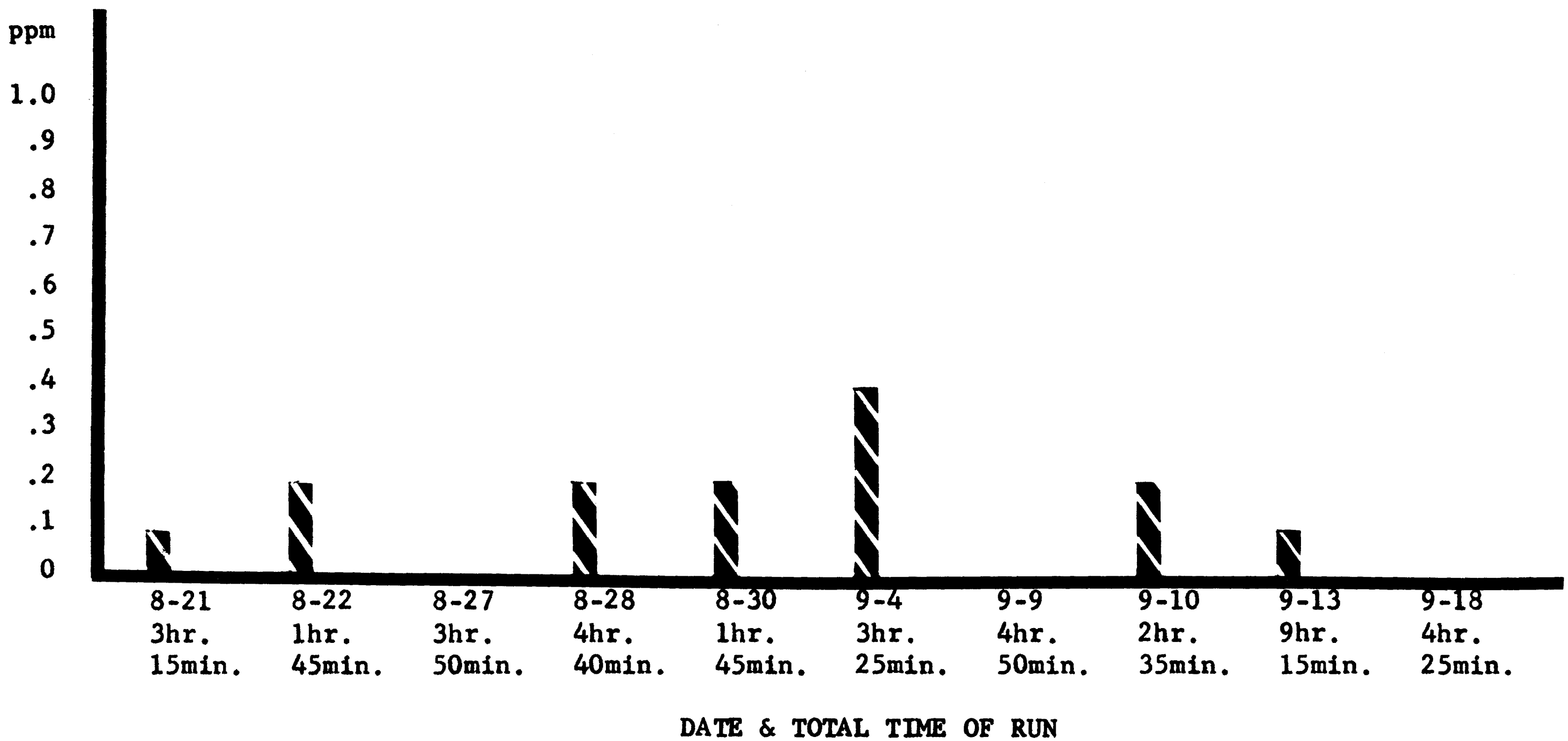
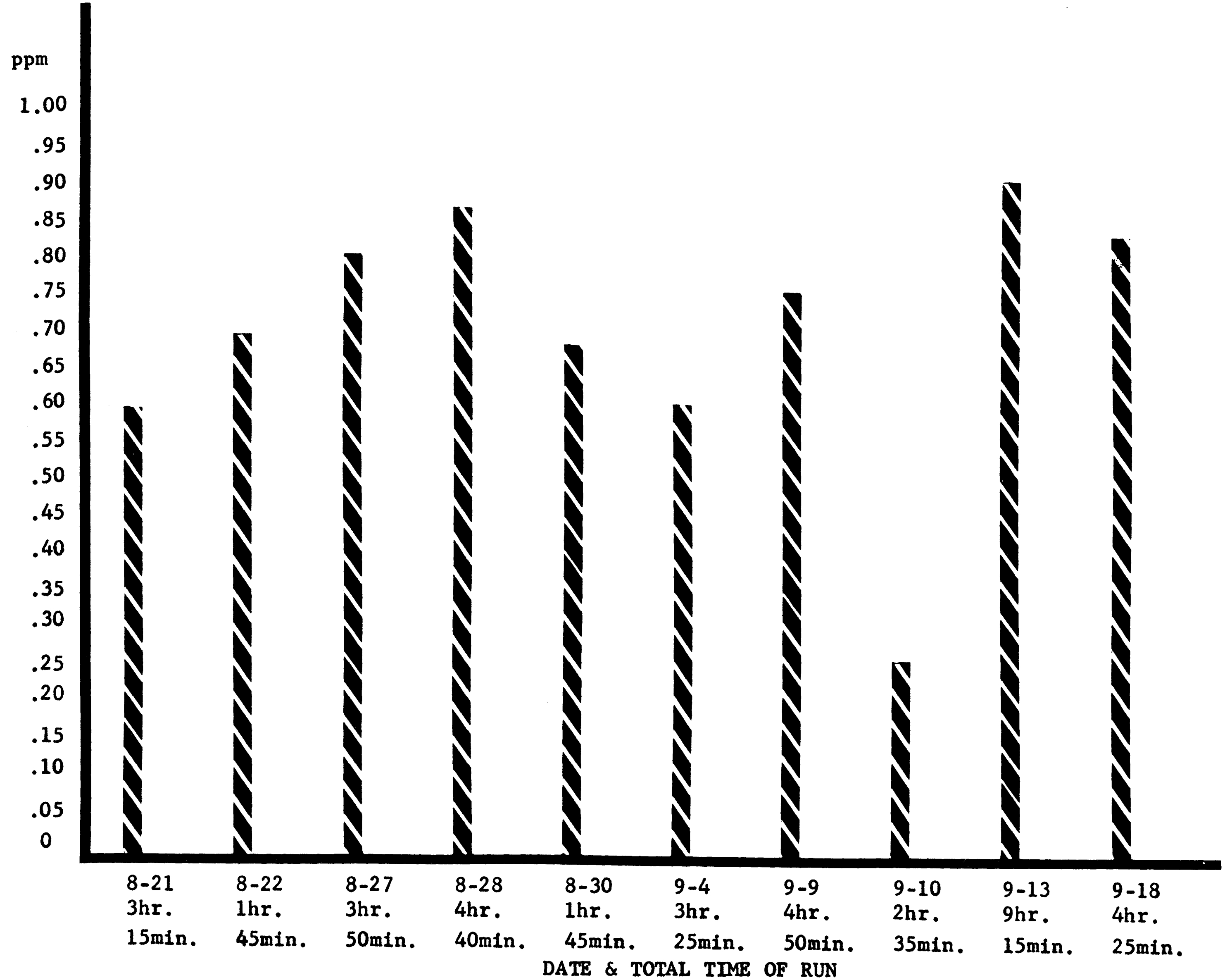
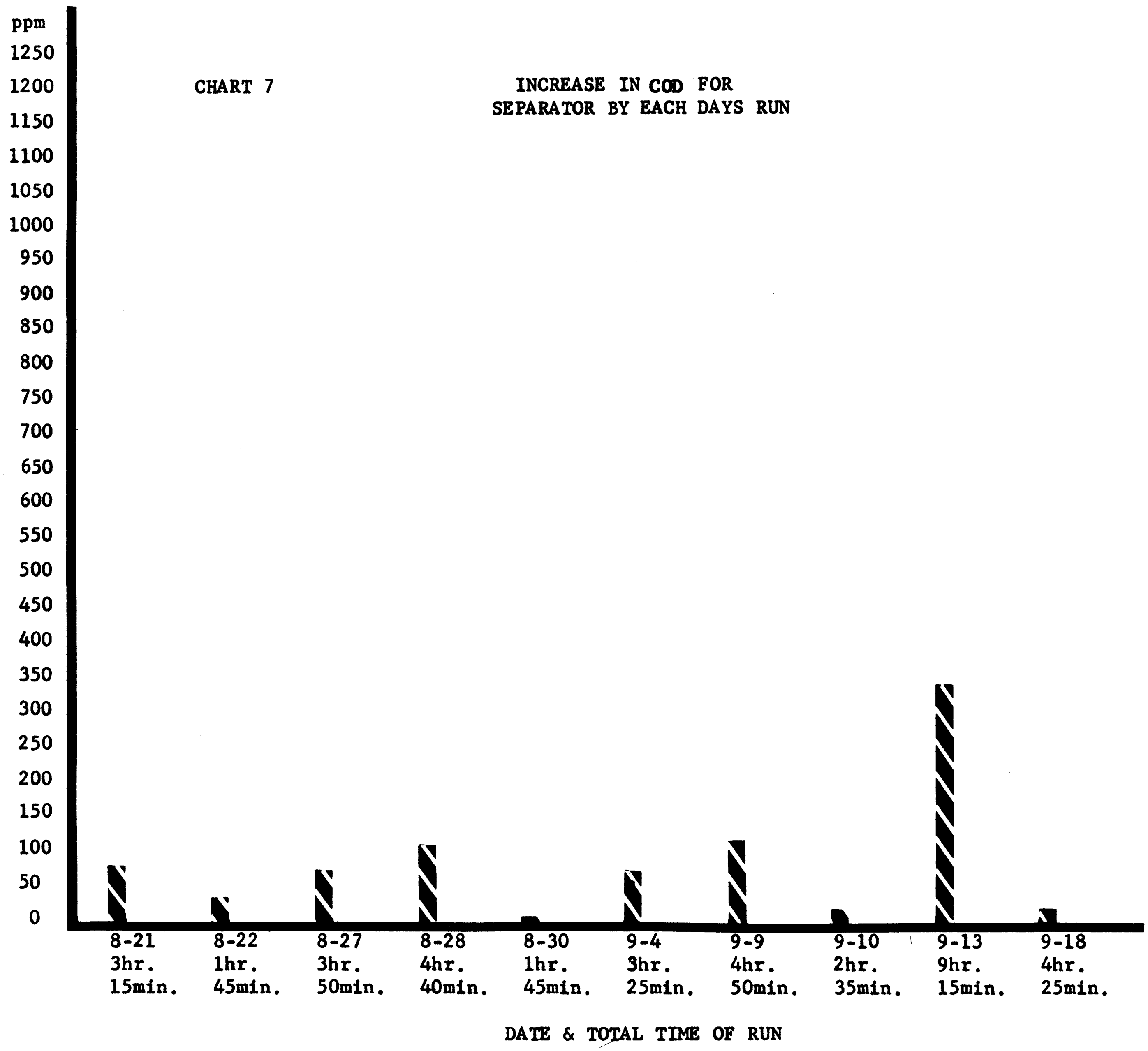


CHART 6

INCREASE IN TOTAL SOLIDS FOR SEPARATOR BY EACH DAYS RUN




ppm
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
CHART 7
INCREASE IN COD FOR
SEPARATOR BY EACH DAYS RUN
8-21 3hr. 15min.
8-22 1hr. 45min.
8-27 3hr. 50min.
8-28 4hr. 40min.
8-30 1hr. 45min.
9-4 3hr. 25min.
9-9 4hr. 50min.
9-10 2hr. 35min.
9-13 9hr. 15min.
9-18 4hr. 25min.
DATE & TOTAL TIME OF RUN

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